Impacts of Road Crossings on Fish and Wildlife

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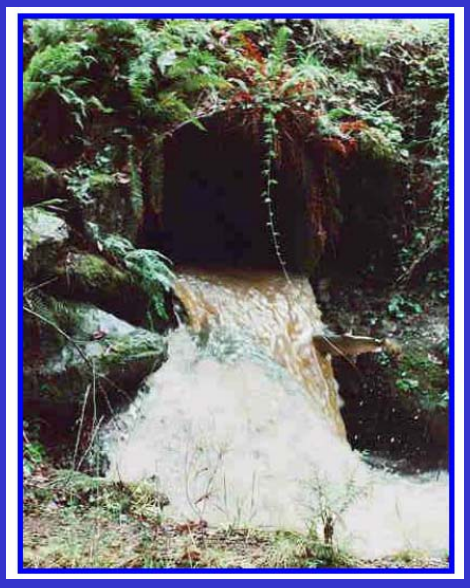
I am a fish biologist, so the presentation will focus on impacts to fish.

Objective



- To provide an overview of biological issues related to stream crossings.

Stream Crossings

- Get you from A to B
- Can impact aquatic species and their habitat
- Good stream crossing design is interdisciplinary

Although good stream crossing design is interdisciplinary, it is not necessarily difficult or expensive.

Stream Crossings Can Affect (among other things):

- Aquatic Organism Passage (AOP)
- Fish and Wildlife Corridors
- Geomorphology (= habitat, erosion/sedimentation, nutrients)

1) Aquatic organisms HAVE to move to maintain their populations.
2) Crossings can directly impact their ability to move upstream and downstream.
3) Crossings can directly and indirectly impact aquatic and riparian habitat near and far from the crossing.
4) There are more than 17,000 stream crossings in New Hampshire, and that number does not include crossings specifically for forestry.

Streams as Fish Habitat

Habitat

- Water quality
- Water depth
- Velocity
- Substrate
- Wood
- Riparian vegetation
- Other vegetation

The take-home message is that each species has specific requirements; the habitat needed by one species may be vastly different than that needed by another species.

Why Fish Move

- To find better habitats

- To avoid threats

Why Fish Move

- Fish need to access the habitat that increases their chances of survival
  - Foraging (have to get to the grocery store)
  - Spawning (live in a good neighborhood)
  - Rearing (take the kids to school)
  - Access new or vacant habitat (new subdivision going in)
- Fish avoid certain areas to increase their chances of survival
  - Water quality (thermal or chemical pollution)
  - Lower (or higher) water levels
  - Changing habitat conditions (e.g., due to ice scour/flood)

Fish move to increase their chances of survival

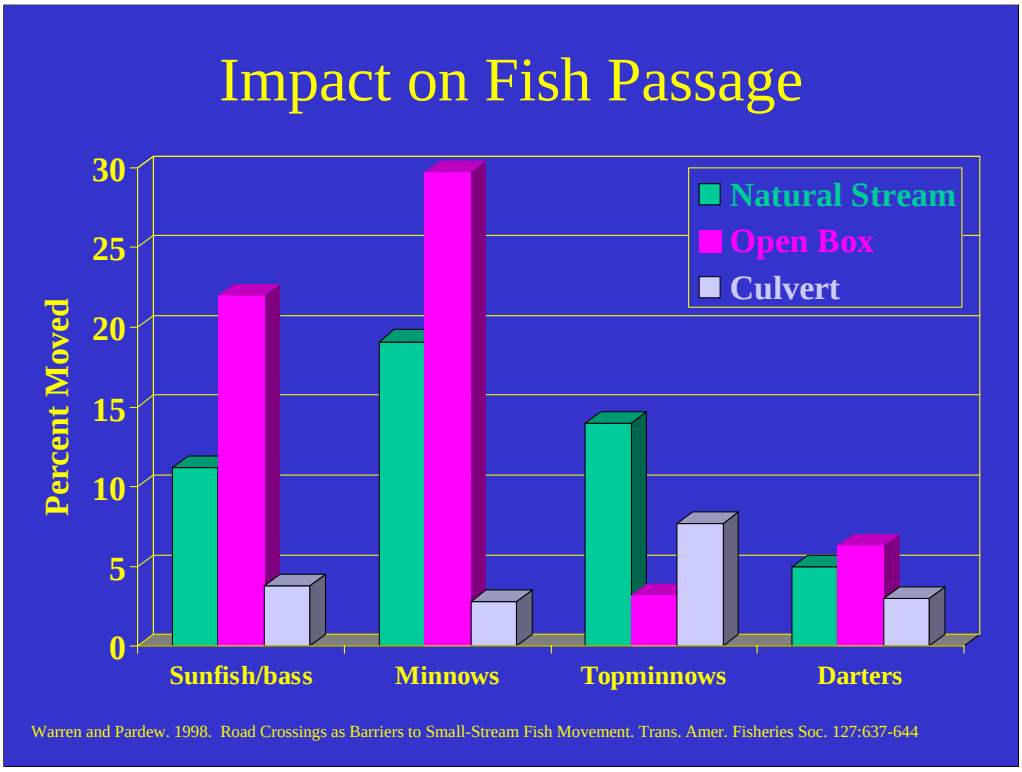
Fish Must Move

- Population health requires short and long-term movement of individuals

This is true for the short- and long-term. An individual fish may not need to move much during its lifetime, but its population requires that individuals move over the long-term.

Fish Move for Various Reasons

- Species specific
  - Some species move:
    - frequently
    - infrequently
    - seasonally
    - very short distances
    - very long distances
    - into intermittent streams



1) The most important comparison in this graph is that between the natural stream sections and the culverts. A smaller proportion of fish moved through the culverts than through the natural stream reaches.
2) A large proportion of some fish families moved through the open box culvert in this study, but that was likely because the water velocities were lower and depths greater at the open box crossings than in the natural stream reaches, which were generally fast-flowing and shallow. Fish have an easier time moving thought slower and deeper water.

Impact on Fish Passage

	False Culvert		Real Culvert	
Group	**Summer**	**Fall**	**Summer**	**Fall**
Trout	13.73	12.28	0.00	5.49
Average	13.00		2.75	
Minnows	5.09	3.89	2.84	1.79
Average	4.49		2.32	
Perch/Sculpin	2.93	0.66	0.79	0.44
Average	1.79		0.62	

- **Behavior plays a role, but may be impossible to quantify**

Coffman. J.S. 2005. Evaluation of a Predictive Model for Upstream Fish Passage Through Culverts. M.S. Thesis. James Madison University

1) A larger proportion of fish in each group moved through the "false culvert" (a natural stream reach just downstream of the culvert) than through the real culverts.
2) Based on the hydraulics of the culverts (water depth and velocity), most fish species were predicted to be able to move upstream through the culverts, but they did not do so in a proportion similar to that for the "false culvert". Therefore, there is a behavioral component to the ability of fish to move upstream through the culverts in this study.
3) It may simply be that fish do not like swimming through long dark tunnels that sound strange to them (many fish "feel" their environment with a specialized sensory organ called the lateral line).

Mussels

Biology- requires host fish for larval stage (glochidia)

Species	Fish host	Status
Brook floater	Longnose dace, golden shiner, slimy sculpin	State endangered
Eastern pondmussel	unknown	Special concern-NH; regional concern-Northeast
Dwarf wedgemussel	Tessellated darter, slimy sculpin, Atlantic salmon	Federal & state endangered

1) The glochidia (larval stage) attaches to the host fish, during which time it can be transported away from its original location…a dispersal mechanism.
2) Many freshwater mussel species require specific fish hosts.
3) If the fish hosts are precluded from moving through an area, then the mussel species may also be precluded from colonizing additional habitat.

Amphibians

Green frog

N. Leopard frog

The following slides contain animals that are not fish, need to move through a diversity of habitats at various times of the year, and travel in and/or near the water.

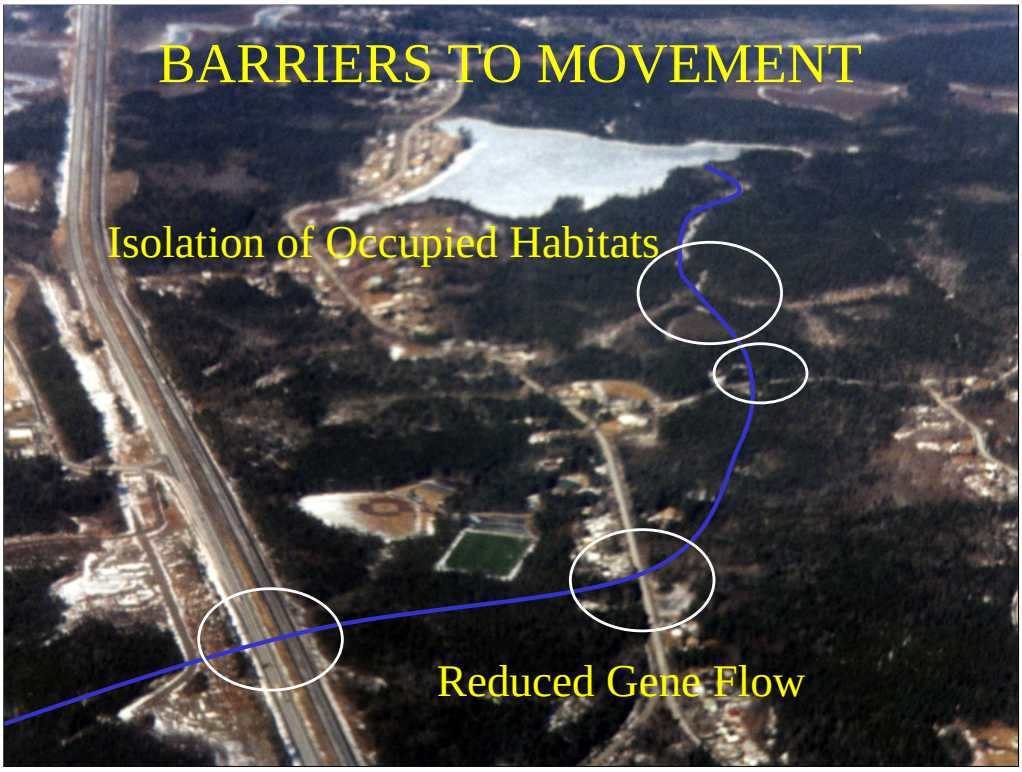
If a crossing precludes them from moving upstream or downstream, they may travel over the road (and risk direct mortality).

NH Stream salamanders

- 2-lined salamander
- Spring salamander
- Northern dusky salamander

Reptiles

Wood turtles require specific substrate into which they lay their eggs. These substrates are often found in floodplains, and are susceptible to impacts from land use, altered hydrology, and altered stream processes (geomorphology).



If populations become fragmented enough, they die out (become extirpated), and are not likely to return until the fragmentation is removed.

The Viability Cornerstone

• The key to viability in fish populations, as we have found with most wildlife populations, is maintaining a system of INTERCONNECTED, diverse, high-quality habitats.

Brian Riggers and Shane Hendrickson, USFS, Lolo National Forest, 2005

Fluvial Geomorphology

- "The study of landform evolution related to stream systems"

  (how flowing water moves sediment and wood)

Leopold, L.B., and T. Maddock Jr., 1953. The Hydraulic Geometry of Stream Channels and Some Physiographic Implications. U.S. Geological Survey Professional Paper 252, 57 pp.

This is a well-documented discipline of engineering – first publication was more than 50 years ago, and the field has continued to flourish with the collection of data over the last 5+ decades. This field of study is one of the most important relative to fish habitat.

Streams need to move "Natural Watershed Products" (wood and sediment).

Fluvial Geomorphology

- Flowing water moves sediment and wood
- Bankfull flow – everything relates to it and the drainage area
  - Channel-forming flow
  - Occurs about every 1.5 years
- Channel Classification – allows for the prediction of how the stream will respond to changes
- Natural Channel Design = Stream Simulation

Ice is often responsible for shaping a channel, and these channels are the way they are because of their response to ice.

Natural Channel Design and Stream Simulation are important components of stream restorations and good stream crossings.

Specific Problems - Geomorph

- Bank erosion
- Sedimentation
- Nutrient/pollutant loading
- Stream warming
- Decrease/elimination of woody debris
- Direct habitat loss

If the geomorphology of a stream is altered, these problems can occur. Some of these can cause impacts to areas upstream and downstream of a site and can also impact other landowners.

Over time…

1979 – Siegel Creek

1998 – Siegel Creek

Photos courtesy of Dan Cemerelli, USFS

The stream was narrowed by the culvert, the resulting water velocities (during annual high water) were increased, and the stream bed eroded leading to a decrease in the elevation of the streambed downstream of the culvert. The culvert is now a fish barrier even though it was originally placed on the streambed.

Undersized Culvert

Bank and streambed erosion on the downstream side of the culvert.

Undersized Culvert

The skewed angle and narrow width of the culvert led to the sediment deposition and bank erosion on the upstream side of the culvert. This area may now be a fish passage barrier at low (and perhaps high) flows. The water depth is likely too shallow to provide fish habitat (indirect impact from the culvert).

Drainage From Road

- **Increased Water Temperature**
- **High salt and sand load**

Crossings are commonly places where sediment and salt directly enter a stream. In the summer, very hot water draining from a dark-colored road can increase the water temperature such that cold water fish (e.g., brook trout) have to either move away from the elevated water temperatures or die.

Poor Crossing for Aquatic Organisms

- Hanging (perched)
- Water drops onto boulder
- Very little water depth
- Dark!

Stream Simulation

- Simulate the Natural Channel in terms of:
  - Width
  - Slope
  - Substrate
  - Water velocities
- Allows for channel stability over a broad range of flows
- Maintains aquatic and riparian habitat
- Provides sustained ecological integrity

Width is not simply the wetted width during any time of year, it is the bankfull width…remember, the bankfull flow is the channel forming flow.

Recommendations for Stream Crossings

- Maintain natural substrate (open bottom is best option)
- Maintain aquatic species passage
- Wider than bankfull width
- Allow for sediment and wood transport
- Maintain storm flow capacity
- Maximize light penetration

Allowing unimpeded wood transport decreases, sometimes dramatically, the cost of maintenance associated with clearing debris from the culvert and complete failure of the culvert.

Conclusions

- Stream crossings can and often lead to:
  - Altered geomorphology (habitat, erosion, sedimentation, nutrients)
  - Disruption/elimination of aquatic organism passage
  - Population impacts
- Fish populations need a system of diverse, ***interconnected***, high-quality habitats.

"Ultimately, our goal should be to create a transportation infrastructure that does not fragment or undermine the essential ecological infrastructure of the land and its waterways."

S. Jackson 2004. Massachusetts River and Stream Crossing Standards: Technical Guidelines